GATE Electronics and Communication Engineering

Sample Paper – 3

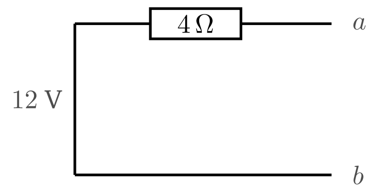
Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Electronics and Communication Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Unless stated otherwise take $n_i = 1.5 \times 10^{10}$ cm^{-3} for silicon, thermal voltage $V_T = 25$ mV at room temperature, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m and $c = 3 \times 10^8$ m/s.

Networks and Circuit Analysis

Q1. A one-port network reduces to an ideal 12 V voltage source in series with a $4\ \Omega$ resistor at terminals a–b, as shown. The Norton equivalent (short-circuit) current seen at a–b is: **[1 mark]**



(A) 48 A

(B) 3 A

(C) 0.33 A

(D) 12 A

Q2. To find the Thevenin resistance at terminals a–b of a network, its independent voltage source is replaced by a short circuit. The remaining resistors are a $6\ \Omega$ in series with the parallel combination of two $12\ \Omega$ resistors. The Thevenin resistance R_{th} is: **[1 mark]**

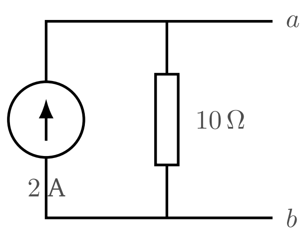
(A) $6\ \Omega$

(B) $18\ \Omega$

(C) $24\ \Omega$

(D) $12\ \Omega$

Q3. A practical source is modelled as a Norton equivalent of current $I_N = 2$ A in parallel with $R_N = 10\ \Omega$, as shown. Its Thevenin equivalent open-circuit voltage $V_{th} = I_N R_N$ is: **[1 mark]**



(A) 20 V

(B) 5 V

(C) 0.2 V

(D) 40 V

Q4. In a resistive network the open-circuit (Thevenin) voltage at terminals a–b equals the voltage across the $6\ \text{k}\Omega$ resistor of a two-resistor divider made of $2\ \text{k}\Omega$ and $6\ \text{k}\Omega$ fed by a 16 V source. That Thevenin voltage is: **[1 mark]**

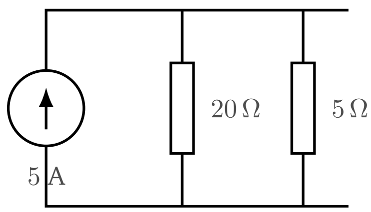
(A) 4 V

(B) 16 V

(C) 12 V

(D) 8 V

Q5. An ideal current source of 5 A is connected in parallel with a $20\ \Omega$ resistor and a $5\ \Omega$ load, as shown. By the current-divider rule the current flowing through the $5\ \Omega$ load is: **[1 mark]**



(A) 5 A

(B) 1 A

(C) 2 A

(D) 4 A

Q6. Two capacitors of $4\ \mu$F and $12\ \mu$F are connected in series between two nodes. The equivalent capacitance of the combination is: **[1 mark]**

(A) $16\ \mu$F

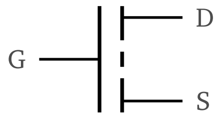
(B) $3\ \mu$F

(C) $8\ \mu$F

(D) $48\ \mu$F

Electronic Devices

Q7. An n-channel enhancement MOSFET has threshold voltage $V_t = 1$ V. It is biased with $V_{GS} = 3$ V and $V_{DS} = 0.5$ V, as shown. Comparing V_{DS} with the overdrive $V_{GS} - V_t$, the transistor is operating in the: **[1 mark]**



(A) triode (linear) region

(B) saturation region

(C) cut-off region

(D) breakdown region

Q8. An n-channel enhancement MOSFET has threshold voltage $V_t = 1$ V. Its gate-to-source voltage is set to $V_{GS} = 0.6$ V while a small drain-to-source voltage is applied. The transistor is operating in the: **[1 mark]**

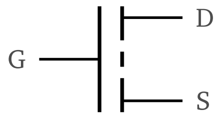
(A) cut-off region

(B) saturation region

(C) triode (linear) region

(D) breakdown region

Q9. An n-channel enhancement MOSFET has threshold voltage $V_t = 0.8$ V. It is biased with $V_{GS} = 2.8$ V and $V_{DS} = 3$ V, as shown. Comparing V_{DS} with the overdrive $V_{GS} - V_t$, the transistor is operating in the: **[1 mark]**



(A) cut-off region

(B) triode (linear) region

(C) saturation region

(D) breakdown region

Q10. An n-channel MOSFET with process transconductance $k_n = 2$ mA/V^2 and threshold $V_t = 0.5$ V is biased in saturation with $V_{GS} = 1.5$ V. Using $I_D = \frac{1}{2}k_n(V_{GS} - V_t)^2$, the drain current is: **[1 mark]**

(A) 1 mA

(B) 2 mA

(C) 0.5 mA

(D) 4 mA

Q11. The MOSFET of the previous style operates in saturation with $k_n = 2$ mA/V^2 and quiescent drain current $I_D = 1$ mA. Its small-signal transconductance $g_m = \sqrt{2\,k_n\,I_D}$ is: **[1 mark]**

(A) 1 mA/V

(B) 4 mA/V

(C) 2 mA/V

(D) 0.5 mA/V

Analog Circuits

Q12. An ideal op-amp inverting amplifier has input resistor $R_1 = 2$ kΩ and feedback resistor $R_f = 8$ kΩ. The magnitude of the closed-loop voltage gain $|V_o/V_i| = R_f/R_1$ is: **[1 mark]**

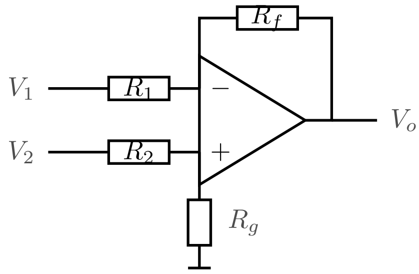
(A) 8

(B) 0.25

(C) 4

(D) 10

Q13. The ideal-op-amp difference (differential) amplifier shown is balanced with $R_1 = R_2 = 10$ kΩ and $R_f = R_g = 30$ kΩ, so that $V_o = \frac{R_f}{R_1}(V_2 - V_1)$. With $V_1 = 1$ V applied through R_1 and $V_2 = 2$ V applied through R_2, the output voltage is: **[1 mark]**



(A) 7 V

(B) 3 V

(C) -3 V

(D) 10 V

Q14. A differential amplifier has a differential-mode gain $A_d = 100$ and a common-mode gain $A_{cm} = 0.1$. Its common-mode rejection ratio in decibels, $\text{CMRR}_{\text{dB}} = 20\log_{10}(A_d/A_{cm})$, is: **[1 mark]**

(A) 40 dB

(B) 20 dB

(C) 60 dB

(D) 80 dB

Q15. An op-amp has a gain–bandwidth product (unity-gain frequency) of 10 MHz. When it is connected for a closed-loop gain of 50, the resulting -3 dB bandwidth is: **[1 mark]**

(A) 10 MHz

(B) 50 kHz

(C) 500 kHz

(D) 200 kHz

Q16. An op-amp has a slew rate of 1 V/μs and drives a sinusoidal output of peak amplitude 2 V. The full-power bandwidth (maximum frequency before slew-rate limiting), $f = \dfrac{\text{SR}}{2\pi V_{peak}}$, is nearest to: **[1 mark]**

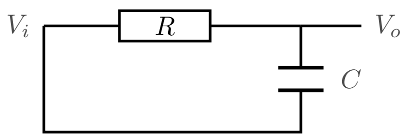
(A) 159 kHz

(B) 79.6 kHz

(C) 500 kHz

(D) 1 MHz

Q17. A first-order RC low-pass filter has $R = 1$ kΩ and $C = 0.1$ μF, as shown. Its -3 dB cut-off frequency $f_c = 1/(2\pi RC)$ is nearest to: **[1 mark]**



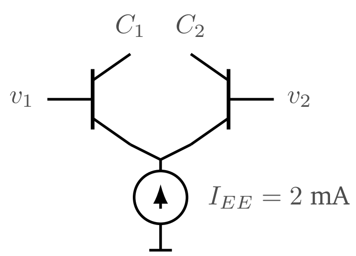
(A) 159 Hz

(B) 15.9 kHz

(C) 100 Hz

(D) 1.59 kHz

Q18. A BJT differential (emitter-coupled) pair is biased by an ideal tail current source $I_{EE} = 2$ mA, as shown. Under balanced (zero differential input) conditions the collector current in each transistor is: **[1 mark]**



(A) 2 mA

(B) 1 mA

(C) 0.5 mA

(D) 4 mA

Digital Circuits

Q19. The hexadecimal number $(2\text{F})_{16}$ has the decimal (base-10) value: **[1 mark]**

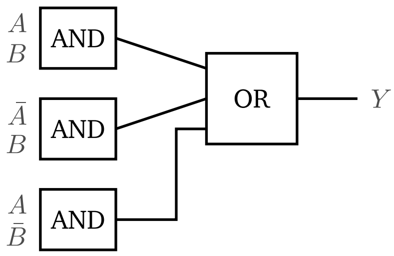
(A) 47

(B) 31

(C) 15

(D) 79

Q20. The three-gate combinational network shown realises $Y = AB + \bar{A}B + A\bar{B}$. Applying the rules of Boolean algebra, this simplifies to: **[1 mark]**



(A) A

(B) B

(C) AB

(D) $A + B$

Q21. The four-variable function $F(A, B, C, D) = \sum m(0, 1, 2, 3)$ is plotted on the Karnaugh map shown (rows AB, columns CD). The minimal sum-of-products expression for F is: **[2 marks]**

$AB \backslash CD$	00	01	11	10
00	1	1	1	1
01	0	0	0	0
11	0	0	0	0
10	0	0	0	0

(A) $\bar{A}\,\bar{B}$

(B) $\bar{A}\,\bar{C}$

(C) $\bar{B}\,\bar{C}$

(D) $\bar{A}B$

Q22. The four-variable function $G(A, B, C, D) = \sum m(0, 4, 8, 12)$ is plotted on the Karnaugh map shown (rows AB, columns CD). The minimal sum-of-products expression for G is: **[2 marks]**

$AB\backslash CD$	00	01	11	10
00	1	0	0	0
01	1	0	0	0
11	1	0	0	0
10	1	0	0	0

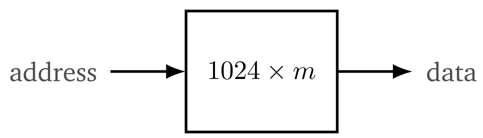
(A) $\bar{A}\,\bar{B}$

(B) CD

(C) $A\bar{B}$

(D) $\bar{C}\,\bar{D}$

Q23. A random-access memory stores 1024 words, addressed one word at a time through the address block shown. The number of address lines needed to select any one word is: **[2 marks]**



(A) 8

(B) 16

(C) 32

(D) 10

Q24. A mod-16 asynchronous (ripple) counter is built from four cascaded flip-flops, each with a propagation delay of 5 ns. The worst-case time for the counter outputs to settle after an active clock edge is: **[2 marks]**

(A) 5 ns

(B) 80 ns

(C) 20 ns

(D) 10 ns

Signals and Systems

Q25. A periodic signal $x(t)$ is a real, odd function of time (that is, $x(-t) = -x(t)$). Its trigonometric Fourier series contains: **[2 marks]**

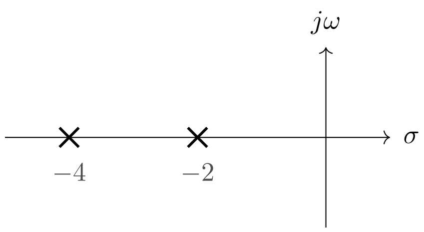
(A) only sine terms

(B) only cosine terms

(C) only a dc term

(D) only even harmonics

Q26. A stable LTI system has the transfer function $H(s) = \dfrac{20}{s^2 + 6s + 8}$, whose pole–zero plot is shown (poles marked $\times$). The d.c. gain $H(0)$ of the system is: **[2 marks]**



(A) 20

(B) 8

(C) 2.5

(D) 5

Q27. A periodic signal is $x(t) = 2 + 3\cos(\omega_0 t) + 4\cos(2\omega_0 t)$. The dc (average) value of $x(t)$, i.e. the Fourier-series coefficient a_0, is: **[2 marks]**

(A) 2

(B) 3

(C) 9

(D) 0

Q28. For the same signal $x(t) = 2 + 3\cos(\omega_0 t) + 4\cos(2\omega_0 t)$, the average power (by Parseval's theorem, summing the dc power and half the square of each harmonic amplitude) is: **[2 marks]**

(A) 29

(B) 4

(C) 12.5

(D) 16.5

Q29. Two finite-length discrete sequences of lengths 5 and 4 samples respectively are linearly convolved. The length (number of samples) of the resulting sequence is: **[2 marks]**

(A) 9

(B) 8

(C) 20

(D) 5

Q30. A continuous-time signal contains spectral components at 1 kHz, 2 kHz and 3 kHz only. The minimum sampling rate (Nyquist rate) needed to reconstruct it without aliasing is: **[2 marks]**

(A) 3 kHz

(B) 12 kHz

(C) 1.5 kHz

(D) 6 kHz

Control Systems

Q31. A standard second-order system has the characteristic equation $s^2 + 6s + 25 = 0$. The damping ratio ζ of the system is: **[2 marks]**

(A) 0.3

(B) 0.6

(C) 1.2

(D) 0.5

Q32. The characteristic equation of a feedback system is $s^3 + 6s^2 + 11s + 6 = 0$. Using the Routh–Hurwitz criterion, the number of closed-loop poles lying in the right half of the s-plane is: **[2 marks]**

(A) 0

(B) 3

(C) 1

(D) 2

Q33. A unity-feedback control system has the open-loop transfer function $G(s) = \dfrac{10}{s(s+2)}$ (a type-1 system). The steady-state error for a unit-step input is: **[2 marks]**

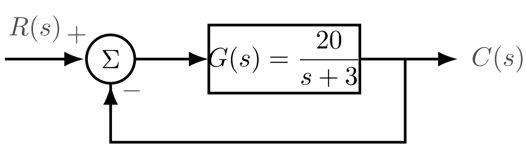
(A) 0

(B) 0.5

(C) 1

(D) 0.2

Q34. For the unity-feedback control system shown, the forward-path transfer function is $G(s) = \dfrac{20}{s+3}$. The d.c. gain of the closed-loop transfer function $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$ (its value at $s = 0$) is nearest to: **[2 marks]**



(A) 20

(B) 0.87

(C) 1

(D) 0.5

Q35. A unity-feedback second-order system has undamped natural frequency $\omega_n = 10$ rad/s and damping ratio $\zeta = 0.5$. The damped natural frequency $\omega_d = \omega_n\sqrt{1-\zeta^2}$ of its transient response is nearest to: **[2 marks]**

(A) 10 rad/s

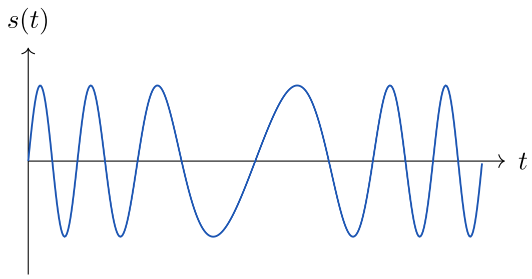
(B) 5 rad/s

(C) 8.66 rad/s

(D) 7.5 rad/s

Communications

Q36. A frequency-modulated (FM) signal, whose constant-envelope waveform is shown, is produced by a modulator of frequency sensitivity $k_f = 10$ kHz/V driven by a single tone of peak amplitude $A_m = 5$ V. The peak frequency deviation $\Delta f = k_f A_m$ is: **[2 marks]**



(A) 10 kHz

(B) 50 kHz

(C) 2 kHz

(D) 100 kHz

Q37. A commercial FM signal has a peak frequency deviation of $\Delta f = 60$ kHz for a modulating tone of frequency $f_m = 10$ kHz. By Carson's rule the transmission bandwidth $B = 2(\Delta f + f_m)$ is: **[2 marks]**

(A) 60 kHz

(B) 70 kHz

(C) 120 kHz

(D) 140 kHz

Q38. A phase-modulated (PM) signal is $s(t) = A\cos\big(\omega_c t + k_p\, m(t)\big)$ with phase sensitivity $k_p = 2$ rad/V. The modulating signal $m(t)$ has a peak amplitude of 3 V. The peak phase deviation $\Delta\phi = k_p\, m_{peak}$ is: **[2 marks]**

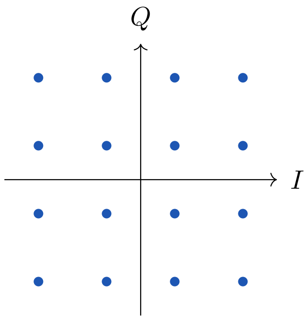
(A) 2 rad

(B) 6 rad

(C) 3 rad

(D) 1.5 rad

Q39. A digital link uses 16-QAM, whose 16-point signal constellation is shown, to carry a bit rate of 8 Mbps. Since 16-QAM transmits 4 bits per symbol, the symbol rate is: **[2 marks]**



(A) 4 Msym/s

(B) 2 Msym/s

(C) 32 Msym/s

(D) 0.5 Msym/s

Q40. A discrete memoryless source emits eight symbols that are all equally likely. The entropy of the source is: **[2 marks]**

(A) 3 bits/symbol

(B) 8 bits/symbol

(C) 1 bit/symbol

(D) 2 bits/symbol

Q41. A communication channel of bandwidth 4 kHz has a signal-to-noise ratio of 15 (as a power ratio). By the Shannon–Hartley law $C = B\log_2(1 + \text{SNR})$, the channel capacity is: **[2 marks]**

(A) 16 kbps

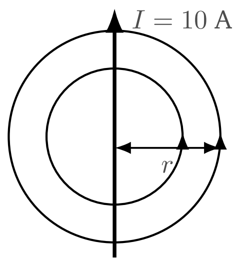
(B) 4 kbps

(C) 8 kbps

(D) 60 kbps

Electromagnetics

Q42. An infinitely long straight wire carries a steady current $I = 10$ A. Using Ampere's circuital law, the magnetic flux density at a radial distance $r = 0.5$ m from the wire, $B = \dfrac{\mu_0 I}{2\pi r}$, is: **[2 marks]**



(A) $1\ \mu$T

(B) $2\ \mu$T

(C) $4\ \mu$T

(D) $8\ \mu$T

Q43. A long air-cored solenoid has $n = 1000$ turns per metre and carries a current $I = 2$ A. By Ampere's law the magnetic flux density on its axis, $B = \mu_0 n I$, is nearest to: **[2 marks]**

(A) 1.26 mT

(B) 2.5 mT

(C) 5 mT

(D) 0.8 mT

Q44. An air-cored toroid has $N = 500$ turns wound on a core of mean radius $r = 0.1$ m and carries a current $I = 2$ A. By Ampere's law the magnetic flux density along the mean circumference, $B = \dfrac{\mu_0 NI}{2\pi r}$, is nearest to: **[2 marks]**

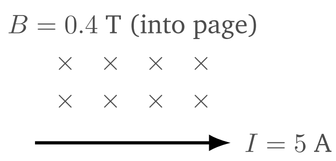
(A) 1 mT

(B) 4 mT

(C) 2 mT

(D) 0.5 mT

Q45. A straight conductor of length $L = 0.2$ m carries a current $I = 5$ A at right angles to a uniform magnetic field $B = 0.4$ T (directed into the page), as shown. The magnitude of the magnetic force on the conductor, $F = BIL$, is: **[2 marks]**



(A) 1 N

(B) 2 N

(C) 0.4 N

(D) 0.1 N

Q46. Two long parallel wires spaced $d = 1$ m apart each carry a current of 10 A in the same direction. By Ampere's law the magnitude of the magnetic force per unit length between them, $\dfrac{F}{L} = \dfrac{\mu_0 I_1 I_2}{2\pi d}$, is: **[2 marks]**

(A) 1×10^{-5} N/m

(B) 4×10^{-5} N/m

(C) 8×10^{-5} N/m

(D) 2×10^{-5} N/m

Detailed Solutions

Q1.

Solution

Concept – Norton current from a Thevenin source: The Norton current is the current that flows when the output terminals are shorted, $I_N = \dfrac{V_{th}}{R_{th}}$.

Step 1 – identify the Thevenin parameters: $V_{th} = 12$ V, $R_{th} = 4\ \Omega$.

Step 2 – short the terminals a–b: With a and b joined, the full source voltage appears across the $4\ \Omega$ resistor.

Step 3 – apply Ohm's law: $I_N = \dfrac{12}{4}$

Step 4 – evaluate: $I_N = 3$ A

Final Answer: $I_N = 3\text{ A} \Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q1**

Q2.

Solution

Concept – Thevenin resistance with sources deactivated: Replace the independent voltage source by a short circuit and reduce the resistor network seen from the terminals.

Step 1 – combine the two parallel resistors: $12\ \Omega \parallel 12\ \Omega = \dfrac{12 \times 12}{12 + 12}$

Step 2 – evaluate the parallel value: $= \dfrac{144}{24} = 6\ \Omega$

Step 3 – add the series resistor: $R_{th} = 6 + 6$

Step 4 – evaluate: $R_{th} = 12\ \Omega$

Final Answer: $R_{th} = 12\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q2**

Q3.

Solution

Concept – source transformation (Norton to Thevenin): A Norton source (I_N, R_N) converts to a Thevenin source with $V_{th} = I_N R_N$ and the same resistance $R_{th} = R_N$.

Step 1 – list the Norton data: $I_N = 2$ A, $R_N = 10\ \Omega$.

Step 2 – multiply to get the open-circuit voltage: $V_{th} = 2 \times 10$

Step 3 – evaluate: $V_{th} = 20$ V

Step 4 – note the resistance is unchanged: $R_{th} = R_N = 10\ \Omega$.

Final Answer: $V_{th} = 20 \text{ V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept – open-circuit (Thevenin) voltage by voltage division: With the output open, no current flows out, so the terminal voltage equals the divider voltage across the chosen resistor, $V_{th} = V_s \dfrac{R_2}{R_1 + R_2}$.

Step 1 – list the data: $V_s = 16$ V, $R_1 = 2$ kΩ, $R_2 = 6$ kΩ.

Step 2 – form the total series resistance: $R_1 + R_2 = 2 + 6 = 8$ kΩ

Step 3 – form the divider ratio: $\dfrac{R_2}{R_1 + R_2} = \dfrac{6}{8} = 0.75$

Step 4 – multiply by the source voltage: $V_{th} = 16 \times 0.75$

Step 5 – evaluate: $V_{th} = 12$ V

Final Answer: $V_{th} = 12 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q4

Q5.

Solution

Concept – current-divider rule: For a current source feeding two parallel resistors, the current in one branch is proportional to the *other* resistor, $I_{load} = I \dfrac{R_{parallel}}{R_{parallel} + R_{load}}$.

Step 1 – list the data: $I = 5$ A, parallel resistor $R_p = 20\ \Omega$, load $R_L = 5\ \Omega$.

Step 2 – form the divider ratio for the load branch: $\dfrac{R_p}{R_p + R_L} = \dfrac{20}{20 + 5} = \dfrac{20}{25}$

Step 3 – simplify the ratio: $= 0.8$

Step 4 – multiply by the source current: $I_{load} = 5 \times 0.8$

Step 5 – evaluate: $I_{load} = 4$ A

Final Answer: $I_{load} = 4 \text{ A} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – capacitors in series: Capacitors in series combine like resistors in parallel, $C_{eq} = \dfrac{C_1 C_2}{C_1 + C_2}$.

Step 1 – list the data: $C_1 = 4\ \mu\text{F}$, $C_2 = 12\ \mu\text{F}$.

Step 2 – form the product: $C_1 C_2 = 4 \times 12 = 48$

Step 3 – form the sum: $C_1 + C_2 = 4 + 12 = 16$

Step 4 – divide: $C_{eq} = \dfrac{48}{16}$

Step 5 – evaluate: $C_{eq} = 3\ \mu\text{F}$

Final Answer: $C_{eq} = 3\ \mu\text{F} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept – MOSFET region test: For an n-channel MOSFET with $V_{GS} > V_t$, the device is in the triode region when $V_{DS} < V_{GS} - V_t$ and in saturation when $V_{DS} \geq V_{GS} - V_t$.

Step 1 – check that the channel is on: $V_{GS} = 3$ V is greater than $V_t = 1$ V, so the channel exists.

Step 2 – compute the overdrive voltage: $V_{GS} - V_t = 3 - 1 = 2$ V

Step 3 – compare V_{DS} with the overdrive: $V_{DS} = 0.5\text{ V} < 2\text{ V}$

Step 4 – classify the region: Because V_{DS} is below the overdrive, the MOSFET is in the **triode (linear) region**.

Why the other options are wrong:

- B, saturation: would need $V_{DS} \geq 2$ V, but here $V_{DS} = 0.5$ V.
- C, cut-off: would need $V_{GS} < V_t$, but $3 > 1$.
- D, breakdown: needs excessive voltage, not present here.

Final Answer: triode (linear) region $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – MOSFET cut-off condition: An enhancement MOSFET conducts only when V_{GS} exceeds the threshold V_t; if $V_{GS} < V_t$ no channel forms and the device is cut off.

Step 1 – read the gate bias: $V_{GS} = 0.6$ V.

Step 2 – compare with the threshold: $V_{GS} = 0.6\text{ V} < V_t = 1\text{ V}$

Step 3 – conclude the channel state: Since the gate voltage is below threshold, no inversion channel forms.

Step 4 – classify the region: With no channel, the drain current is essentially zero, so the device is in the **cut-off region**.

Final Answer: cut-off region $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – MOSFET saturation condition: For $V_{GS} > V_t$, the MOSFET saturates when $V_{DS} \geq V_{GS} - V_t$.

Step 1 – check that the channel is on: $V_{GS} = 2.8$ V is greater than $V_t = 0.8$ V, so a channel exists.

Step 2 – compute the overdrive voltage: $V_{GS} - V_t = 2.8 - 0.8 = 2\text{ V}$

Step 3 – compare V_{DS} with the overdrive: $V_{DS} = 3\text{ V} \geq 2\text{ V}$

Step 4 – classify the region: Because V_{DS} exceeds the overdrive, the channel pinches off at the drain and the device is in the **saturation region**.

Why the other options are wrong:

- A, cut-off: needs $V_{GS} < V_t$, but $2.8 > 0.8$.
- B, triode: needs $V_{DS} < 2$ V, but here $V_{DS} = 3$ V.
- D, breakdown: needs a junction voltage beyond its rating, not the case here.

Final Answer: saturation region $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – saturation drain current of a MOSFET: In saturation $I_D = \frac{1}{2}k_n\,(V_{GS} - V_t)^2$.

Step 1 – compute the overdrive voltage: $V_{GS} - V_t = 1.5 - 0.5 = 1$ V

Step 2 – square the overdrive: $(V_{GS} - V_t)^2 = 1^2 = 1\ \text{V}^2$

Step 3 – substitute into the current equation: $I_D = \frac{1}{2} \times (2\ \text{mA/V}^2) \times 1$

Step 4 – evaluate: $I_D = 1$ mA

Final Answer: $I_D = 1\ \text{mA} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – MOSFET transconductance in saturation: The small-signal transconductance can be written as $g_m = \sqrt{2\,k_n\,I_D}$.

Step 1 – list the data: $k_n = 2\ \text{mA/V}^2$, $I_D = 1$ mA.

Step 2 – form the product $2k_nI_D$: $2 \times 2 \times 1 = 4$

Step 3 – take the square root: $g_m = \sqrt{4}$

Step 4 – evaluate: $g_m = 2$ mA/V

Final Answer: $g_m = 2\ \text{mA/V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept – gain of an inverting op-amp: For an ideal inverting amplifier the gain magnitude is $|A_v| = \frac{R_f}{R_1}$.

Step 1 – list the resistor values: $R_f = 8\ \text{k}\Omega$, $R_1 = 2\ \text{k}\Omega$.

Step 2 – form the ratio: $|A_v| = \frac{8\ \text{k}\Omega}{2\ \text{k}\Omega}$

Step 3 – evaluate: $|A_v| = 4$

Final Answer: $|A_v| = 4 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q12

Q13.

Solution

Concept – balanced difference amplifier: When $R_1 = R_2$ and $R_f = R_g$, the output of the op-amp difference amplifier is $V_o = \frac{R_f}{R_1}(V_2 - V_1)$.

Step 1 – form the resistor ratio: $\frac{R_f}{R_1} = \frac{30\ \text{k}\Omega}{10\ \text{k}\Omega} = 3$

Step 2 – form the input difference: $V_2 - V_1 = 2 - 1 = 1$ V

Step 3 – multiply: $V_o = 3 \times 1$

Step 4 – evaluate: $V_o = 3$ V

Why the other options are wrong:

- A, 7 V: wrongly adds the inputs instead of subtracting.
- C, -3 V: reverses the sign; the non-inverting input carries the larger voltage, so V_o is positive.
- D, 10 V: ignores the difference and misuses the gain.

Final Answer: $V_o = 3\ \text{V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – common-mode rejection ratio in decibels: $\text{CMRR} = \frac{A_d}{A_{cm}}$, and in decibels $\text{CMRR}_{\text{dB}} = 20\log_{10}\left(\frac{A_d}{A_{cm}}\right)$.

Step 1 – form the ratio of gains: $\frac{A_d}{A_{cm}} = \frac{100}{0.1}$

Step 2 – evaluate the ratio: $= 1000$

Step 3 – take the base-10 logarithm: $\log_{10}(1000) = 3$

Step 4 – multiply by 20: $\text{CMRR}_{\text{dB}} = 20 \times 3$

Step 5 – evaluate: $\text{CMRR}_{\text{dB}} = 60$ dB

Final Answer: $\text{CMRR}_{\text{dB}} = 60\ \text{dB} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – gain–bandwidth product: For a single-pole op-amp the product of closed-loop gain and bandwidth is constant, so $\text{BW} = \dfrac{\text{GBW}}{A_{CL}}$.

Step 1 – list the data: $\text{GBW} = 10\text{ MHz} = 10 \times 10^6\text{ Hz}$, $A_{CL} = 50$.

Step 2 – divide: $\text{BW} = \dfrac{10 \times 10^6}{50}$

Step 3 – evaluate: $\text{BW} = 0.2 \times 10^6\text{ Hz}$

Step 4 – express in kilohertz: $\text{BW} = 200\text{ kHz}$

Final Answer: $\text{BW} = 200\text{ kHz} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q15**

Q16.

Solution

Concept – slew-rate-limited full-power bandwidth: The highest sinusoidal frequency an op-amp can reproduce without slew-rate distortion is $f = \dfrac{\text{SR}}{2\pi V_{peak}}$.

Step 1 – convert the slew rate to base units: $\text{SR} = 1\text{ V}/\mu\text{s} = 1 \times 10^6\text{ V/s}$

Step 2 – form the denominator: $2\pi V_{peak} = 2\pi \times 2 = 12.566$

Step 3 – divide: $f = \dfrac{1 \times 10^6}{12.566}$

Step 4 – evaluate: $f = 79.6 \times 10^3\text{ Hz} = 79.6\text{ kHz}$

Final Answer: $f \approx 79.6\text{ kHz} \Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q16**

Q17.

Solution

Concept – cut-off frequency of a first-order RC low-pass filter: $f_c = \dfrac{1}{2\pi RC}$.

Step 1 – convert the values to base units: $R = 1\text{ k}\Omega = 1 \times 10^3\ \Omega$

$C = 0.1\ \mu\text{F} = 0.1 \times 10^{-6}\text{ F} = 1 \times 10^{-7}\text{ F}$

Step 2 – form the product RC: $RC = (1 \times 10^3) \times (1 \times 10^{-7}) = 1 \times 10^{-4}\text{ s}$

Step 3 – form $2\pi RC$: $2\pi RC = 6.2832 \times 10^{-4}$

Step 4 – invert: $f_c = \dfrac{1}{6.2832 \times 10^{-4}}$

Step 5 – evaluate: $f_c \approx 1591$ Hz ≈ 1.59 kHz

Final Answer: $f_c \approx 1.59$ kHz $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept – current split in a balanced differential pair: An emitter-coupled pair driven by a tail current source shares that current equally between the two transistors when the differential input is zero.

Step 1 – read the tail current: $I_{EE} = 2$ mA.

Step 2 – apply the balance condition: With $v_1 = v_2$, symmetry forces $I_{C1} = I_{C2}$.

Step 3 – split the tail current equally: $I_{C1} = I_{C2} = \dfrac{I_{EE}}{2} = \dfrac{2}{2}$

Step 4 – evaluate: Each collector current $= 1$ mA.

Final Answer: 1 mA per transistor $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – hexadecimal to decimal conversion: Each hex digit is weighted by a power of 16: $(d_1 d_0)_{16} = d_1 \times 16 + d_0$.

Step 1 – identify the digit values: The digit 2 has value 2; the digit F has value 15.

Step 2 – weight the most significant digit: $2 \times 16 = 32$

Step 3 – add the least significant digit: $32 + 15$

Step 4 – evaluate: $(2\text{F})_{16} = 47$

Final Answer: $47 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – Boolean simplification: Combine like terms using $X+X=X$, $A+\bar{A}=1$ and $A+\bar{A}B=A+B$.

Step 1 – write the expression: $Y=AB+\bar{A}B+A\bar{B}$

Step 2 – combine the first two terms (factor B): $AB+\bar{A}B=B(A+\bar{A})=B(1)=B$

Step 3 – substitute back: $Y=B+A\bar{B}$

Step 4 – apply the absorption identity $B+A\bar{B}=B+A$**:** $Y=A+B$

Final Answer: $Y=A+B \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – Karnaugh-map grouping: Adjacent 1-cells are grouped in powers of two; the variables that stay constant over the group appear in the product term.

Step 1 – locate the minterms: m_0, m_1, m_2, m_3 all lie in the top row, where $AB=00$.

Step 2 – group the four cells of that row: A group of four cells spanning all columns of the $AB=00$ row is formed.

Step 3 – find the constant variables over the group: Across the group $A=0$ and $B=0$ throughout, while C and D change.

Step 4 – write the product term: Constant $A=0$ gives $\bar{A}$ and constant $B=0$ gives $\bar{B}$, so $F=\bar{A}\,\bar{B}$.

Final Answer: $F=\bar{A}\,\bar{B} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – Karnaugh-map grouping: Group adjacent 1-cells and keep only the variables that remain constant over the group.

Step 1 – locate the minterms: m_0, m_4, m_8, m_{12} all lie in the left column, where $CD=00$.

Step 2 – group the four cells of that column: A group of four cells spanning all rows of the $CD = 00$ column is formed.

Step 3 – find the constant variables over the group: Across the group $C = 0$ and $D = 0$ throughout, while A and B change.

Step 4 – write the product term: Constant $C = 0$ gives $\bar{C}$ and constant $D = 0$ gives $\bar{D}$, so $G = \bar{C}\,\bar{D}$.

Final Answer: $G = \bar{C}\,\bar{D} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – address lines for a memory: To uniquely select one of N words, the number of address lines is $\lceil \log_2 N \rceil$.

Step 1 – list the data: $N = 1024$ words.

Step 2 – express 1024 **as a power of two:** $1024 = 2^{10}$

Step 3 – take the base-2 logarithm: $\log_2(2^{10}) = 10$

Step 4 – state the number of lines: 10 address lines are required.

Final Answer: 10 address lines $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q23

Q24.

Solution

Concept – worst-case delay of a ripple counter: In an asynchronous counter each flip-flop clocks the next, so delays add and the worst case is $t_{worst} = (\text{number of stages}) \times t_{pd}$.

Step 1 – list the data: Number of flip-flops $= 4$ (mod-16 needs $2^4 = 16$ states), $t_{pd} = 5$ ns each.

Step 2 – identify the longest chain: The last flip-flop can change only after all four have toggled in sequence.

Step 3 – add the delays: $t_{worst} = 4 \times 5$

Step 4 – evaluate: $t_{worst} = 20$ ns

Final Answer: $t_{worst} = 20$ ns $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – Fourier series and waveform symmetry: The trigonometric Fourier series of a real signal keeps cosine terms for the even part and sine terms for the odd part; a purely odd signal has no cosine or dc content.

Step 1 – classify the signal: $x(t)$ is odd: $x(-t) = -x(t)$.

Step 2 – test the dc (average) term: The average of an odd function over a full period is zero, so $a_0 = 0$.

Step 3 – test the cosine coefficients: Cosine is even, so the product $x(t)\cos(n\omega_0 t)$ is odd and integrates to zero; all cosine coefficients vanish.

Step 4 – identify what remains: Only the sine terms (the odd basis functions) can be nonzero.

Final Answer: only sine terms $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – d.c. gain of a transfer function: The d.c. gain is the value of $H(s)$ at $s = 0$.

Step 1 – substitute $s = 0$: $H(0) = \dfrac{20}{0^2 + 6(0) + 8}$

Step 2 – evaluate the denominator: $0 + 0 + 8 = 8$

Step 3 – divide: $H(0) = \dfrac{20}{8}$

Step 4 – evaluate: $H(0) = 2.5$

Final Answer: $H(0) = 2.5 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

Concept – dc term of a Fourier series: In $x(t) = a_0 + \sum a_n \cos(n\omega_0 t) + \ldots$, the constant a_0 is the time-average (dc) value.

Step 1 – write the signal: $x(t) = 2 + 3\cos(\omega_0 t) + 4\cos(2\omega_0 t)$

Step 2 – note the average of each cosine: Each cosine term averages to zero over a full period.

Step 3 – keep only the constant term: The time-average of $x(t)$ equals the constant 2.

Step 4 – state the coefficient: $a_0 = 2$

Final Answer: $a_0 = 2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – average power by Parseval's theorem: For a sum of a dc term and cosines, $P = a_0^2 + \sum \frac{A_k^2}{2}$, where A_k is each harmonic amplitude.

Step 1 – compute the dc power: $a_0^2 = 2^2 = 4$

Step 2 – compute the power of the first harmonic: $\frac{3^2}{2} = \frac{9}{2} = 4.5$

Step 3 – compute the power of the second harmonic: $\frac{4^2}{2} = \frac{16}{2} = 8$

Step 4 – add the contributions: $P = 4 + 4.5 + 8$

Step 5 – evaluate: $P = 16.5$

Final Answer: $P = 16.5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept – length of a linear convolution: Convolving sequences of lengths L_1 and L_2 gives a sequence of length $L_1 + L_2 - 1$.

Step 1 – list the lengths: $L_1 = 5$, $L_2 = 4$.

Step 2 – add the lengths: $L_1 + L_2 = 5 + 4 = 9$

Step 3 – subtract one: $9 - 1 = 8$

Step 4 – state the result: The output has 8 samples.

Final Answer: 8 samples $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – Nyquist rate: A band-limited signal must be sampled at at least twice its highest frequency component.

Step 1 – identify the highest frequency: The components are at 1, 2 and 3 kHz, so $f_{max} = 3$ kHz.

Step 2 – double the highest frequency: $f_s^{min} = 2 \times 3$

Step 3 – evaluate: $f_s^{min} = 6$ kHz

Final Answer: $f_s^{min} = 6 \text{ kHz} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – damping ratio from the characteristic equation: Comparing $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$ with the given equation gives $\omega_n = \sqrt{\text{constant}}$ and $\zeta = \dfrac{\text{coefficient of } s}{2\omega_n}$.

Step 1 – read the constant term: $\omega_n^2 = 25$, so $\omega_n = 5$ rad/s.

Step 2 – read the coefficient of s: $2\zeta\omega_n = 6$

Step 3 – solve for ζ: $\zeta = \dfrac{6}{2 \times 5} = \dfrac{6}{10}$

Step 4 – evaluate: $\zeta = 0.6$

Final Answer: $\zeta = 0.6 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q31

Q32.

Solution

Concept – Routh–Hurwitz stability test: The number of right-half-plane poles equals the number of sign changes in the first column of the Routh array.

Step 1 – write the coefficients: For $s^3 + 6s^2 + 11s + 6$: row s^3 gives $[1,\ 11]$, row s^2 gives $[6,\ 6]$.

Step 2 – compute the s^1 row: $\dfrac{6 \times 11 - 1 \times 6}{6} = \dfrac{66 - 6}{6} = \dfrac{60}{6} = 10$

Step 3 – compute the s^0 row: The last entry carries down as 6.

Step 4 – inspect the first column: The first column is $1,\ 6,\ 10,\ 6$: all positive, with no sign changes.

Step 5 – conclude: Zero sign changes means zero poles in the right half-plane; the system is stable.

Final Answer: 0 RHP poles $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – steady-state error of a type-1 system to a step: For a step input the error is $e_{ss} = \dfrac{1}{1+K_p}$ with $K_p = \lim_{s\to 0} G(s)$; a type-1 system (a pole at the origin) makes K_p infinite.

Step 1 – evaluate the position error constant: $K_p = \lim_{s\to 0} \dfrac{10}{s(s+2)}$

Step 2 – take the limit: As $s \to 0$ the factor s in the denominator drives $K_p \to \infty$.

Step 3 – substitute into the error formula: $e_{ss} = \dfrac{1}{1+\infty}$

Step 4 – evaluate: $e_{ss} = 0$

Why it makes sense: A type-1 open loop has one integrator, which drives the steady-state step error to exactly zero.

Final Answer: $e_{ss} = 0 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q33

Q34.

Solution

Concept – d.c. gain of a closed loop: The closed-loop transfer function is $\dfrac{C}{R} = \dfrac{G}{1+G}$; its d.c. gain is obtained at $s = 0$.

Step 1 – evaluate the forward gain at $s = 0$: $G(0) = \dfrac{20}{0+3} = \dfrac{20}{3} = 6.667$

Step 2 – form the numerator of the closed-loop gain: Numerator $= G(0) = 6.667$

Step 3 – form the denominator: $1 + G(0) = 1 + 6.667 = 7.667$

Step 4 – divide: $\left.\dfrac{C}{R}\right|_{s=0} = \dfrac{6.667}{7.667}$

Step 5 – evaluate: ≈ 0.87

Final Answer: d.c. gain $\approx 0.87 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q34

Q35.

Solution

Concept – damped natural frequency: For an underdamped second-order system $\omega_d = \omega_n\sqrt{1-\zeta^2}$.

Step 1 – list the data: $\omega_n = 10$ rad/s, $\zeta = 0.5$.

Step 2 – square the damping ratio: $\zeta^2 = 0.5^2 = 0.25$

Step 3 – form $1-\zeta^2$: $1 - 0.25 = 0.75$

Step 4 – take the square root: $\sqrt{0.75} = 0.866$

Step 5 – multiply by ω_n: $\omega_d = 10 \times 0.866 = 8.66$ rad/s

Final Answer: $\omega_d \approx 8.66$ rad/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – peak frequency deviation in FM: The instantaneous frequency of an FM signal deviates from the carrier by $\Delta f = k_f\,A_m$ for a tone of amplitude A_m.

Step 1 – list the data: $k_f = 10$ kHz/V, $A_m = 5$ V.

Step 2 – multiply: $\Delta f = 10 \times 5$

Step 3 – evaluate: $\Delta f = 50$ kHz

Final Answer: $\Delta f = 50$ kHz $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – Carson's rule for FM bandwidth: The transmission bandwidth is $B = 2(\Delta f + f_m)$.

Step 1 – list the data: $\Delta f = 60$ kHz, $f_m = 10$ kHz.

Step 2 – add the deviation and modulating frequency: $\Delta f + f_m = 60 + 10 = 70$ kHz

Step 3 – multiply by two: $B = 2 \times 70$

Step 4 – evaluate: $B = 140$ kHz

Final Answer: $B = 140$ kHz $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – peak phase deviation in PM: For $s(t) = A\cos(\omega_c t + k_p m(t))$ the peak phase deviation is $\Delta\phi = k_p\, m_{peak}$.

Step 1 – list the data: $k_p = 2$ rad/V, $m_{peak} = 3$ V.

Step 2 – multiply: $\Delta\phi = 2 \times 3$

Step 3 – evaluate: $\Delta\phi = 6$ rad

Final Answer: $\Delta\phi = 6$ rad $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – symbol rate from bit rate: $R_s = \dfrac{R_b}{\log_2 M}$, where M is the number of constellation points.

Step 1 – find the bits per symbol: 16-QAM has $M = 16$, so $\log_2 16 = 4$ bits per symbol.

Step 2 – list the bit rate: $R_b = 8$ Mbps.

Step 3 – divide: $R_s = \dfrac{8}{4}$

Step 4 – evaluate: $R_s = 2$ Msym/s

Final Answer: $R_s = 2$ Msym/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – entropy of an equiprobable source: For M equally likely symbols the entropy is $H = \log_2 M$ bits/symbol.

Step 1 – list the data: $M = 8$ equally likely symbols.

Step 2 – express 8 **as a power of two:** $8 = 2^3$

Step 3 – take the base-2 logarithm: $H = \log_2(2^3) = 3$

Step 4 – state the result: $H = 3$ bits/symbol

Final Answer: $H = 3$ bits/symbol $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q40

Q41.

Solution

Concept – Shannon–Hartley channel capacity: $C = B\log_2(1 + \text{SNR})$.

Step 1 – list the data: $B = 4$ kHz, SNR $= 15$.

Step 2 – form the term inside the logarithm: $1 + \text{SNR} = 1 + 15 = 16$

Step 3 – take the base-2 logarithm: $\log_2(16) = 4$

Step 4 – multiply by the bandwidth: $C = 4$ kHz $\times 4$

Step 5 – evaluate: $C = 16$ kbps

Final Answer: $C = 16$ kbps $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q41

Q42.

Solution

Concept – Ampere's law for a long straight wire: The field encircling a long straight wire is $B = \dfrac{\mu_0 I}{2\pi r}$.

Step 1 – list the data: $\mu_0 = 4\pi \times 10^{-7}$ H/m, $I = 10$ A, $r = 0.5$ m.

Step 2 – form the numerator: $\mu_0 I = (4\pi \times 10^{-7}) \times 10 = 4\pi \times 10^{-6}$

Step 3 – form the denominator: $2\pi r = 2\pi \times 0.5 = \pi$

Step 4 – divide: $B = \dfrac{4\pi \times 10^{-6}}{\pi} = 4 \times 10^{-6}$ T

Step 5 – express in microtesla: $B = 4\ \mu$T

Final Answer: $B = 4\ \mu\text{T} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

Q43.

Solution

Concept – Ampere's law for a long solenoid: The axial field of a long solenoid is $B = \mu_0 n I$, with n the turns per metre.

Step 1 – list the data: $\mu_0 = 4\pi \times 10^{-7}$ H/m, $n = 1000$ turns/m, $I = 2$ A.

Step 2 – multiply n and I: $nI = 1000 \times 2 = 2000$

Step 3 – multiply by μ_0: $B = (4\pi \times 10^{-7}) \times 2000 = 8\pi \times 10^{-4}$

Step 4 – evaluate numerically: $B = 8 \times 3.1416 \times 10^{-4} = 2.51 \times 10^{-3}$ T

Step 5 – express in millitesla: $B \approx 2.5$ mT

Final Answer: $B \approx 2.5\ \text{mT} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – Ampere's law for a toroid: Along the mean circumference of a toroid $B = \dfrac{\mu_0 N I}{2\pi r}$.

Step 1 – list the data: $\mu_0 = 4\pi \times 10^{-7}$ H/m, $N = 500$, $I = 2$ A, $r = 0.1$ m.

Step 2 – form the numerator: $\mu_0 N I = (4\pi \times 10^{-7}) \times 500 \times 2 = 4\pi \times 10^{-4}$

Step 3 – form the denominator: $2\pi r = 2\pi \times 0.1 = 0.2\pi$

Step 4 – divide: $B = \dfrac{4\pi \times 10^{-4}}{0.2\pi} = 20 \times 10^{-4}$ T

Step 5 – express in millitesla: $B = 2 \times 10^{-3}\ \text{T} = 2$ mT

Final Answer: $B = 2\ \text{mT} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – force on a current-carrying conductor: For a conductor perpendicular to a uniform field, $F = BIL$.

Step 1 – list the data: $B = 0.4$ T, $I = 5$ A, $L = 0.2$ m.

Step 2 – multiply the field and the current: $BI = 0.4 \times 5 = 2$

Step 3 – multiply by the length: $F = 2 \times 0.2$

Step 4 – evaluate: $F = 0.4$ N

Final Answer: $F = 0.4 \text{ N} \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q45**

Q46.

Solution

Concept – force per unit length between parallel currents: Two long parallel wires exert $\dfrac{F}{L} = \dfrac{\mu_0 I_1 I_2}{2\pi d}$ on each other.

Step 1 – list the data: $\mu_0 = 4\pi \times 10^{-7}$ H/m, $I_1 = I_2 = 10$ A, $d = 1$ m.

Step 2 – form the numerator: $\mu_0 I_1 I_2 = (4\pi \times 10^{-7}) \times 10 \times 10 = 4\pi \times 10^{-5}$

Step 3 – form the denominator: $2\pi d = 2\pi \times 1 = 2\pi$

Step 4 – divide: $\dfrac{F}{L} = \dfrac{4\pi \times 10^{-5}}{2\pi} = 2 \times 10^{-5}$

Step 5 – state the result with units: $\dfrac{F}{L} = 2 \times 10^{-5}$ N/m

Final Answer: $\dfrac{F}{L} = 2 \times 10^{-5} \text{ N/m} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q46**

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	A	4	C	5	D
6	B	7	A	8	A	9	C	10	A
11	C	12	C	13	B	14	C	15	D
16	B	17	D	18	B	19	A	20	D
21	A	22	D	23	D	24	C	25	A
26	C	27	A	28	D	29	B	30	D
31	B	32	A	33	A	34	B	35	C
36	B	37	D	38	B	39	B	40	A
41	A	42	C	43	B	44	C	45	C
46	D								